Implementing Cisco Quality of Service
QOS v2.5; 5 days, Instructor-led

Course Description
Implementing Cisco Quality of Service (QOS) v2.5 provides learners with in-depth knowledge of QoS requirements, conceptual models such as best effort, IntServ, and DiffServ, and the implementation of QoS on Cisco platforms. The curriculum covers the theory of QoS, design issues, and configuration of various QoS mechanisms to facilitate the creation of effective administrative policies providing QoS. Case studies and lab exercises included in the course help learners to apply the concepts from the individual modules to real-life scenarios. The course also gives learners design and usage rule for advanced QoS features. This gives the learners the opportunity to design and implement efficient, optimal, and trouble-free multiservice networks.

Audience Profile
The primary audience for this course is as follows:
- Pre- and post-sales technical engineers responsible for designing, implementing, or troubleshooting networks
- Network architects responsible for designing multiservice networks to carry voice, video, and data traffic in enterprise or service provider environments
- Advanced Unified Communications Specialization
- Master UC Specialization
- Master Telepresence ATP

The secondary audience for this course is as follows:
- CCIE R&S Candidates

Course Completion
Upon completing this course, the learner will be able to meet these overall objectives:
- You will be able to identify, describe, and correctly implement the appropriate QoS mechanisms required to create an effective administrative policy providing QoS

Prerequisites
The knowledge and skills that a learner must have before attending this course are as follows:
- Interconnecting Cisco Networking Devices, Part 1 and 2 (ICND1 and ICND2)
- Cisco Certified Networking Associate

Course Outline
Module 1: Introduction to QoS
Lesson 1: Review Converged Networks
- Converged Networks
- Quality Issues in Converged Networks
- Available Bandwidth
Lesson 2: Understand QoS
- QoS Defined
- QoS Policy Defined
- Implement a QoS Policy
- Identify Network Traffic
- Voice Traffic Profile
- Videoconferencing Traffic Profile
- Cisco TelePresence Traffic Profile
- Data Traffic Profile
- Divide Network Traffic into Classes
- Define Policies for Traffic Classes
- QoS Mechanisms
- QoS Implementation Methods
- QoS Monitoring Methods
- Cisco Medianet QoS Design
- Summary

Case Study 1-1: QoS Mechanisms
- Task 1: Apply QoS Mechanisms

Lesson 3: Describe Best-Effort and Integrated Services Models
- QoS Models
- Best-Effort QoS Model
- IntServ Model
- Resource Reservation Protocol
- RSVP Components
- RSVP Interface Bandwidth Queuing
- Summary

Lesson 4: Describe the Differentiated Services Model
- DiffServ Model
- DiffServ Terminology
- DSCP Encoding
- Per-Hop Behaviors
- Expedited Forwarding
- Assured Forwarding
- AF Drop Probability
- Class Selector
- Integration of IntServ and DiffServ
- Summary
Lesson 5: Module Summary
- References

Lesson 6: Module Self-Check

Module 2: Implement and Monitor QoS
Lesson 1: MQC Introduction
- Modular QoS CLI
- MQC Components
- Example: MQC Policy Configuration
- Class Maps Overview
- Match Operation in Class Maps
- Policy Maps Overview
- Service Policy Overview
- Hierarchical Policy
- Summary

Lesson 2: Monitor QoS
- SNMP Management of QoS
- Describe Class-Based QoS MIB
- Cisco NBAR
- Cisco NBAR Protocol Discovery
- Cisco NBAR Protocol Discovery MIB
- NetFlow
- Cisco Flexible NetFlow
- Cisco Flexible NetFlow Integration with NBAR
- Class-Based Flexible NetFlow
- Cisco Performance Monitor
- Cisco Mediatrace
- Cisco IP SLA
- IP SLA: UDP Jitter
- Summary

Lab 2-1: IP SLA Setup and QoS Baseline Measurement
- Task 1: Verify Network Connectivity
- Task 2: Create a Baseline Measurement of Network Traffic
- Task 3: Measure the Network Performance Under Traffic Load
- Task 4: QoS Measurement Lab Results

Lesson 3: Define Campus AutoQoS
- AutoQoS
- AutoQoS Macros
- Trust Boundaries
- Campus AutoQoS Trust
- Campus AutoQoS Conditional Trust
- Campus AutoQoS Video
Lesson 4: Define WAN AutoQoS
- Cisco AutoQoS for Routers
- WAN AutoQoS VoIP
- AutoQoS for the Enterprise Overview
- Configuring AutoQoS for the Enterprise
- Monitoring AutoQoS in the WAN
- Summary

Lab 2-2: Configuring QoS with Cisco AutoQoS
- Task 1: Configure Cisco AutoQoS Classify on the Catalyst 2960-S Switch
- Task 2: Configure Cisco AutoQoS for the Enterprise on Cisco IOS Routers
- Task 3: Measure Network Performance with Cisco AutoQoS for the Enterprise
- Task 4: QoS Measurement Results

Lesson 5: Module Summary
- References

Lesson 6: Module Self-Check

Module 3: Classification and Marking
Lesson 1: Classification and Marking Overview
- Classification
- Marking
- Classification and Marking at the Data Link Layer
- Classification and Marking at the Network Layer
- Mapping QoS Marking Between OSI Layers
- QoS Service Class Defined
- Service Class Templates
- RFC 4594 Marking Recommendations
- Summary

Case Study 3-1: Classification and Marking
- Task 1: Classification and Marking
- Task 2: Identify Network Locations Where Classification and Marking Should Be Applied

Lesson 2: MQC for Classification and Marking
- MQC Classification Options
- Configuring Class Maps
- Monitoring Classification
- MQC Marking Options
- Configuring Class-Based Marking
• Monitoring Class-Based Marking
• Configuring IPv6 Classification and Marking
• Summary

Lab 3-2: Classification and Marking Using MQC
• Task 1: Configure an IP Extended Access List
• Task 2: Configure MQC Classification
• Task 3: Configure Class-Based Marking

Lesson 3: NBAR for Classification
• Cisco NBAR
• NBAR Application Support
• Configuring NBAR With MQC
• Classifying HTTP Traffic
• NBAR2 Application Grouping
• NBAR Port Map
• NBAR Custom Protocols
• Configuring Custom Protocols
• NBAR Worm Policing
• NBAR versus Future Worms
• Summary

Lab 3-3: Using NBAR for Classification
• Task 1: Upgrade the NBAR Protocol Pack
• Task 2: Discover Applications and Traffic by Using NBAR
• Task 3: Configure Classification with NBAR

Lesson 4: Use of QoS Preclassify
• Issues with QoS on VPNs
• ToS Byte Preservation
• QoS Preclassify Operation
• Configuring QoS Preclassify
• Monitoring QoS Preclassify
• Summary

Lab 3-4: Configuring QoS Preclassify
• Task 1: Configure a GRE Tunnel
• Task 2: Configure QoS Preclassify

Lesson 5: Campus Classification and Marking
• Campus Classification and Marking
• Overview of QoS Trust Boundaries
• Campus Ingress QoS Models
• QoS Map Tables: Marking
• Internal DSCP
• Applying Campus Switch Classification and Marking
• Monitoring Campus Classification and Marking
• Summary

Lab 3-5: Campus Classification and Marking Using MQC
• Task 1: Configure a Trust Boundary
• Task 2: Configure CoS-to-DSCP Mapping
• Task 3: Configure Class-Based Marking
• Task 4: Verify QoS Markings
• Task 5: Adjust Router Classification and Marking Policy

Lesson 6: Module Summary
• References

Lesson 7: Module Self-Check

Module 4: Congestion Management
Lesson 1: Queuing Introduction
• Congestion and Queuing
• Queuing Components
• Hardware Queue Size
• Congestion on Logical Interfaces
• Queuing Algorithms
• FIFO Queuing
• Priority Queuing
• Round-Robin Queuing
• WRR Queuing
• DRR Queuing
• Summary

Lesson 2: Configure WFQ
• Weighted Fair Queuing
• WFQ Classification
• WFQ Scheduling
• WFQ Drop Operation
• Benefits and Drawbacks of WFQ
• Configuring WFQ
• Monitoring WFQ
• Summary

Lab 4-1: Configuring Fair Queuing
• Task 1: Configure Fair Queuing
• Task 2: Measure Network Performance with Fair Queuing
• Task 3: Adjust the Fair Queuing Configuration
• Task 4: Measure Network Performance with Fair Queuing Configured with 256 Dynamic Queues
• Task 5: QoS Measurement Lab Results
Lesson 3: Configure CBWFQ and LLQ
- Class-Based Weighted Fair Queuing
- CBWFQ Architecture
- Benefits and Drawbacks of CBWFQ
- Configuring CBWFQ
- Low Latency Queuing
- LLQ Architecture
- Configuring LLQ
- Monitoring LLQ-CBWFQ
- Summary

Lab 4-2: Configuring LLQ-CBWFQ
- Task 1: Configure a CBWFQ Policy with LLQ
- Task 2: Apply and Monitor CBWFQ with LLQ Operation
- Task 3: Measure Network Performance with CBWFQ
- Task 4: QoS Measurement Lab Results

Lesson 4: Configure Campus Congestion Management
- Campus Queuing
- Catalyst Switch Hardware Queue Nomenclature
- Queue Mapping
- WRR on Campus Switches
- WRR Bandwidth and Buffer Settings
- SRR on Campus Switches
- SRR Common and Reserved Buffers
- Configuring Ingress Queuing on Cisco Catalyst 3750 Series Switches
- Configuring Egress Queuing on Cisco Catalyst 3750 Series Switches
- Monitoring Congestion Management On Cisco Catalyst 3750 Series Switches
- Summary

Lab 4-3: Configuring Campus-Based Queuing Mechanisms
- Task 1: Review Egress Queuing Defaults
- Task 2: Configure Global Egress Queuing Parameters
- Task 3: Configure and Monitor Egress Queuing

Lesson 5: Module Summary
- References

Lesson 6: Module Self-Check

Module 5: Congestion Avoidance
Lesson 1: Congestion Avoidance Introduction
- TCP Behavior
- Congestion and TCP
- Example: TCP Congestion Control Algorithms
- Managing Congestion with Tail Drop
- Impact of Tail Drop
- Random Early Detection
- RED Profiles and Modes
- TCP Behavior Before and After RED
- Summary

**Lesson 2: Configure Class-Based WRED**
- Weighted Random Early Detection
- Class-Based WRED
- WRED Building Blocks
- WRED Profiles
- IP Precedence-Based WRED
- DSCP-Based WRED
- Configure CBWRED
- Changing WRED Sensitivity to Bursts
- Example: DSCP-Based WRED
- Monitoring CBWRED
- Summary

**Case Study 5-1: WRED Traffic Profiles**
- Task 1: Create WRED Traffic Profiles

**Lesson 3: Configure ECN**
- Explicit Congestion Notification
- ECN Field
- ECN and WRED
- ECN Operation
- Configuring ECN
- Monitoring ECN
- Summary

**Lab 5-2: Configuring DSCP-Based WRED**
- Task 1: Configure DSCP-Based WRED
- Task 2: Monitor DSCP-Based WRED
- Task 3: Configure DSCP-Based CBWRED with ECN
- Task 4: Monitor DSCP-Based WRED with ECN

**Lesson 4: Describe Campus-Based Congestion Avoidance**
- Congestion Avoidance in the Campus
- Weighted Tail Drop
- Configuring WTD Thresholds on the Cisco Catalyst 3750 Series Switch
- WRED on Campus Switches
- Dynamic Buffer Limiting
- Summary
Lab 5-3: Configuring WTD Thresholds
- Task 1: Configure and Monitor Weighted Tail Drop

Lesson 5: Module Summary
- References

Lesson 6: Module Self-Check

Module 6: Traffic Policing and Shaping
Lesson 1: Traffic Policing and Shaping Overview
- Traffic Policing and Traffic Shaping
- Policing and Shaping Use Cases
- Policing vs. Shaping
- Single Token Bucket Model
- Single Token Bucket Class-Based Policing
- Dual Token Bucket Class-Based Policing
- Dual-Rate Token Bucket Class-Based Policing
- Class-Based Traffic Shaping
- Summary

Lesson 2: Configure Class-Based Policing
- Class-Based Policing
- Configuring Class-Based Policing
- Example: Single-Rate Single Token Policer
- Example: Single-Rate Dual Token Policer
- Example: Dual-Rate Policer
- Monitoring Class-Based Policing
- Summary

Lesson 3: Campus Policing
- Campus Policing Overview
- QoS Map Tables: Policing
- Applying Campus Switch Policing
- Campus Aggregate Policing
- Campus Microflow Policing
- Summary

Lab 6-1: Configuring Class-Based Policing
- Task 1: Configure Single Token Bucket Class-Based Policing
- Task 2: Monitor Single Token Bucket Class-Based Policing
- Task 3: Configure Dual Token Bucket Class-Based Policing
- Task 4: Monitor Dual Token Bucket Class-Based Policing

Lesson 4: Configure Class-Based Shaping
- Class-Based Shaping
- Shaping Methods
• Configuring Class-Based Shaping
• Example: Shaping Configuration
• Example: Hierarchical Shaping
• Monitoring Class-Based Shaping
• Summary

Lab 6-2: Configuring Class-Based Shaping
• Task 1: Migrate Traffic to the MPLS Service
• Task 2: Configure Class-Based Shaping
• Task 3: Configure Hierarchical Shaping

Lesson 5: Configure Class-Based Shaping on Frame Relay Interfaces
• Frame Relay Refresher
• Frame Relay Congestion Control
• Frame Relay Congestion Adaptation
• FECN-to-BECN Propagation
• Configuring Adaptive Class-Based Shaping
• Monitoring FRTS
• Summary

Lesson 6: Configure Frame Relay Voice-Adaptive Traffic Shaping and Fragmentation
• Frame Relay Voice-Adaptive Traffic Shaping and Fragmentation
• Benefits of Frame Relay Voice-Adaptive Traffic Shaping and Fragmentation
• Frame Relay Voice-Adaptive Traffic Shaping and Fragmentation Operation
• Configuring Frame Relay Voice-Adaptive Traffic Shaping and Fragmentation
• Monitoring Frame Relay Voice-Adaptive Traffic Shaping and Fragmentation
• Summary

Lesson 7: Module Summary
• References

Lesson 8: Module Self-Check

Module 7: Link Efficiency Mechanisms
Lesson 1: Link Efficiency Mechanisms Overview
• Link Efficiency Mechanisms
• Layer 2 Payload Compression
• Header Compression
• Large Packet "Freeze Out"
• Serialization Delay
• Link Fragmentation and Interleaving
• Fragment Size Recommendations for Voice
• Summary

Lesson 2: Configure Class-Based Header Compression
• Header Compression
Class-Based TCP Header Compression
Example: Class-Based TCP Header Compression Configuration
Class-Based RTP Header Compression
Example: Class-Based RTP Header Compression
Configuring Class-Based Header Compression
Monitoring Class-Based Header Compression
Summary

Lab 7-1: Configuring Class-Based Header Compression
- Task 1: Configure Class-Based Header Compression
- Task 2: Monitor Class-Based Header Compression

Lesson 3: Configure LFI
- LFI Options
- Configuring MLP with Interleaving
- Monitoring MLP Interleaving
- FRF.12 Frame Relay Fragmentation
- Configuring FRF.12 Frame Relay Fragmentation
- Monitoring FRF.12 Frame Relay Fragmentation
- Summary

Lab 7-2: Configuring LFI
- Task 1: Configure LFI
- Task 2: Monitor LFI

Lesson 4: Module Summary
- References

Lesson 5: Module Self-Check

Module 8: Deploying End-to-End QoS
Lesson 1: Apply Best Practices for QoS Policy Design
- Optimally Deploying QoS Within the Enterprise
- Strategically Defining QoS Objectives
- Cisco Modified RFC 4594 Marking Recommendations and Class Expansion
- Understanding Application Service-Level Requirements
- QoS Requirements for Control Plane Traffic
- Control Plane Policing
- Data Plane Policing
- Classification and Marking Best Practices
- Policing and Markdown Best Practices
- Queuing and Dropping Best Practices
- Link Efficiency Mechanisms Best Practices
- Summary
Lesson 2: End-to-End QoS Deployments
- Deploying End-to-End QoS
- Enterprise Campus QoS Guidelines
- Campus QoS Deployment Steps and Options
- Branch Router QoS Guidelines
- WAN Edge QoS Design Considerations
- Enterprise Network with Layer 2 Service
- Enterprise Network with Layer 3 Service
- QoS Service Level Agreements
- QoS Implications of Layer 3 Service Offerings
- Enterprise-to-Service Provider QoS Class Mapping
- Re-Marking DSCP at SP MPLS Edge
- Summary

Lab 8-1: Mapping Enterprise QoS Policy to the Service Provider Policy
- Task 1: Adjust QoS Markings to Match the Service Provider QoS Policy
- Task 2: Re-mark Inbound Traffic from the Service Provider

Lesson 3: Module Summary
- References

Lesson 4: Module Self-Check